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AUTHOR Woehlke, Paula L.
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ABSTRACT

Evaluation of the Attitudes Toward Statistics Scale (ATS) of S. L. Wise (1985) was extended by examining scale responses in relation to: (1) the scale's factor structure; and (2) the correlation of ATS subscale scores with students' grades in statistics courses at several levels of graduate study, students' sex, and scores on measures of basic mathematics and comprehension of statistical terminology. In the spring of 1990, data were obtained from 193 students in masters' and doctoral basic and advanced statistics courses, including one on experimental design. High degrees of factorial and predictive validity were found for the ATS. Factors that emerged were identical to those derived by Wise. Subscale scores correlated with students' grades overall at the different levels. ATS COURSE subscale scores were the single best predictor of student grades in the experimental design course. The ATS appears promising as an adjunct to mathematics-related variables in predicting performance in graduate-level statistics courses. Five tables present study data. A six-item list of references is included. (SLD)

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AN EXAMINATION OF THE FACTOR STRUCTURE OF WISE'S *ATTITUDE TOWARD STATISTICS* SCALE

Paula L. Woehlke
Southern Illinois University Carbondale

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Concern for college students' attitudes toward statistics have been evident for some time and seldom do such organizations as the American Educational Research Association and the American Statistical Association meet without at least one symposium or seminar on the issue. The reasons for such concern are not hard to find. As noted by Hinkle, Wiersmaz & Jurs (1988), "Often statistics provides the basic rationale behind planning and decision making by educators, counselors, and others whose work is tied to the behavioral sciences" (p. 2). Hildebrand (1986) says that "Statistical thinking is a major part of scientific thinking, particularly in psychology, education, and all social sciences" (p. 1). However, as noted by Mattson (1981), typical students in a statistics class "are persons who have struggled as average students in mathematics classes" (p. vii) and are both intimidated and confused by mathematical concepts. As a result, several scales have been devised to measure students' attitudes, as aids in attempts to discover methods of altering students' attitudes toward this crucial topic. Most of these scales have been tied closely to particular courses or intended for use with undergraduate students (Wise, 1985). However, Wise devised a more general scale designed to measure attitudes toward statistics; he had three goals in mind: (a) items had to be attitudinal, not addressing students' success or problems with statistics; (b) items had to be answerable on both the first and last days of class; and (c) two dimensions were to be assessed, statistics as a field and the particular class being taken (Wise, 1985). As a result of his work, Wise devised a 29-item scale that met the preceding criteria and yielded acceptable internal consistency and test-retest reliability, as well as evidence of factorial and criterion-related validity.

The purpose of the present study was to extend the evaluation of Wise's *Attitudes Toward Statistics* (ATS) Scale by examining scale responses in relation to (a) its factor structure and (b) the correlation of ATS subscale scores with students' grades in statistics courses at several levels of graduate study, students' sex (which was found to be a useful predictor by Woehlke & Leitner, 1980), and scores on measures of basic mathematics and comprehension of statistical terminology

METHOD

At the start of the spring, 1990 semester, students in four levels of graduate statistics courses at Southern Illinois University Carbondale were asked to participate in a study of variables related to achievement in statistics. They completed a *Student Diagnostic Survey* (SDS) and a Cloze test of statistics-related terminology as previously used by Woehlke & Leitner (1980) as well as the ATS. They also granted permission for their instructors to release their course grades at the end of the semester. During final examination week instructors were supplied with names and social security numbers of participants and asked to provide grades received by the students. Data were obtained from 193 students: 34 in a masters-level basic statistics course; 88 in a doctoral-level inferential statistics class; 55 studying doctoral-level multiple linear regression; 15 in a doctoral-level course in experimental design; and one student who failed to designate the course being taken. Data were coded and entered into *SYSTAT 5.0* (1989) running on a Macintosh IIcx computer.

RESULTS AND DISCUSSION

Descriptive Statistics

Tables 1 and 2 contain descriptive data for all subjects overall and by course. These tables generally show the expected trends of means for all variables; that is, scores on the SDS, Cloze, ATS FIELD and ATS COURSE tended to increase with course level and increasing familiarity with and/or liking for statistics, except that ATS COURSE scores were lower for those in the doctoral-level inferential statistics and multiple linear regression courses; it should be noted that these two courses are required by many graduate departments throughout the university while the experimental design course is an elective for all but doctoral-level educational measurement and statistics majors. In examining the correla-

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tions among the variables, one can see that overall, the ATS COURSE subscale correlated moderately with SDS scores, while the ATS FIELD score was related to SDS, Grade, and ATS COURSE values. For students in the masters-level course, ATS COURSE scores were correlated with all other measures. For students in the doctoral-level inferential statistics classes, ATS FIELD scores were related to SDS responses, and ATS COURSE values correlated with the SDS and ATS FIELD subscale. However, for the doctoral-level multiple linear regression course, only the ATS COURSE subscale showed correlations to any of the other variables, namely the SDS and ATS FIELD scores. Data from the doctoral-level experimental design students showed only that ATS COURSE scores were related to course grades.

Factor Analysis

A preliminary principal components analysis indicated two factors in the ATS. A subsequent principal axis factor analysis with varimax rotation yielded the results shown in Table 3. It is noteworthy that, without exception, all items loaded on the same factor, and in the same direction, as found by Wise (1985) in his initial analysis, indicating a high degree of factorial validity.

Multiple Regression Analyses

Subsequent multiple regression analyses attempting to predict course grades from responses to the SDS, Cloze, and ATS subscales yielded equivocal results. Table 4 shows a series of multiple regression analyses attempting to predict course grades using various combinations of test scores and other information. For example, all test scores, course taken, sex, and the interaction of the latter two yielded an R^2 of .117; while statistically significant, it is hardly impressive. R^2 decreased to .113 when the interaction terms were omitted, and stayed the same when student sex was deleted. When test scores and sex were used as predictors, R^2 was .111; test scores alone produced an R^2 of .110; SDS and Cloze

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scores yielded an R^2 of ..105; ATS FIELD and ATS COURSE scores as predictors of grade produced an R^2 of .037; and ATS subscale scores plus course gave an R^2 of .042. In every equation containing SDS. the scores were significant ($p<.05$) semi-partial contributors to predicting grades.

When multiple regression equations relating test scores and students' sex to grades were run, results varied greatly by course. As shown in Table 5, R^2's for the masters-level course were moderate (.360) with or without students' sex being included in the model. R^2 values were much lower for the inferential statistics class (.189 and .186 with and without students' sex in the model, respectively). Even lower were similar R^2's for multiple linear regression students (.031 and .025, respectively); but for the experimental design course, the R^2 for test scores and students' sex was .862, while that using scores only as predictors was .818. These results are particularly intriguing when one considers that the experimental design students' standard deviation for course grade was considerably smaller (0.389) than that for any other course (1.100 to 1.232). ATS COURSE was a particularly effective predictor of students' grades for this design course.

CONCLUSIONS

In spite of the homogeneity of the sample used in this study, the ATS received support for its factorial and predictive validity. The factors that emerged from the present data were identical to those derived by Wise (1985). In addition, ATS COURSE subscale scores correlated with students' grades overall and for the masters-level and experimental design students. Finally, ATS COURSE subscale scores were the single best predictor of students' grades in the experimental design course. The ATS appears to offer promise as an adjunct to mathematics-related variables in predicting performance in graduate-level statistics courses.

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TABLE 1
Descriptive Statistics For Combined Groups

	SDS	CLOZE	GRADE	ATS FIELD	ATS COURSE
N OF CASES	193	193	183	191	190
MEAN	14.984	10.932	3.459	78.691	30.179
STD DEV	3.706	3.214	1.108	9.467	8.071
SKEWNESS	-0.965	-1.524	-2.266	-0.426	-0.423
KURTOSIS	0.648	2.684	4.223	0.034	-0.342

Correlations[1]

	SDS	CLOZE	GRADE	ATS FIELD
CLOZE	0.273*			
GRADE	0.319*	0.147*		
ATS FIELD	0.251*	0.024	0.141	
ATS COURSE	0.550*	0.130	0.188*	0.573*

[1]N=178

*p<.05

TABLE 2
Descriptive Statistics by Course

Masters-level (N = 34)

	SDS	CLOZE	GRADE	ATS FIELD	ATS COURSE
N OF CASES	34	34	32	34	33
MEAN	14.147	9.794	3.438	76.265	30.879
STD DEV	4.076	3.282	1.134	8.280	6.767
SKEWNESS	-1.233	-0.979	-2.135	-0.027	-0.718
KURTOSIS	1.536	0.763	3.467	-0.362	0.544

Correlations

	SDS	CLOZE	GRADE	ATS FIELD
CLOZE	0.418*			
GRADE	0.573*	0.326		
ATS FIELD	0.113	0.216	0.191	
ATS COURSE	0.453*	0.399*	0.411*	0.646*

Doctoral-level Inferential Statistics (N = 88)

	SDS	CLOZE	GRADE	ATS FIELD	ATS COURSE
N OF CASES	88	88	88	87	86
MEAN	14.760	10.864	3.409	78.471	29.907
STD DEV	3.708	3.371	1.100	9.399	8.217
SKEWNESS	-0.730	-1.720	-2.112	-0.382	-0.456
KURTOSIS	-0.108	3.144	3.875	-0.260	-0.317

Correlations

	SDS	CLOZE	GRADE	ATS FIELD
CLOZE	0.191			
GRADE	0.400*	0.221*		
ATS FIELD	0.238*	-0.076	0.109	
ATS COURSE	0.544*	0.053	0.188	0.567*

Doctoral-level Multiple Regression (N = 55)

	SDS	CLOZE	GRADE	ATS FIELD	ATS COURSE
N OF CASES	55	55	50	54	55
MEAN	15.327	11.564	3.460	79.500	29.182
STD DEV	3.742	2.595	1.232	10.343	8.665
SKEWNESS	-0.852	-1.091	-2.253	-0.714	-0.169
KURTOSIS	-0.009	1.246	3.542	0.587	-0.644

Correlations

	SDS	CLOZE	GRADE	ATS FIELD
CLOZE	0.374*			
GRADE	0.017	-0.099		
ATS FIELD	0.263	0.003	0.116	
ATS COURSE	0.634*	0.228	0.047	0.607*

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TABLE 2 (cont.)

Doctoral-level Experimental Design (N = 15)

	SDS	CLOZE	GRADE	ATS FIELD	ATS COURSE
N OF CASES	15	15	12	15	15
MEAN	16.800	11.667	3.833	82.400	34.400
STD DEV	1.859	3.792	0.389	8.650	6.770
SKEWNESS	-0.389	-2.035	-1.789	-0.411	-0.607
KURTOSIS	-0.322	4.087	1.200	0.008	-0.633

Correlations

	SDS	CLOZE	GRADE	ATS FIELD
CLOZE	-0.055			
GRADE	0.535	0.158		
ATS FIELD	0.433	-0.066	0.448	
ATS COURSE	0.496	0.038	0.888*	0.464

*p<.05

TABLE 3
Results of Factor Analysis

PRINCIPAL COMPONENTS FACTOR EXTRACTION
PERCENT OF TOTAL VARIANCE EXPLAINED

1	2	3	4	5	6	7	8
35.44157	12.38850	4.85497	3.86816	3.82074	3.47267	3.23181	2.87100
9	10	11	12	13	14	15	16
2.76859	2.52657	2.33388	2.27129	2.03748	1.90481	1.81446	1.73603
17	18	19	20	21	22	23	24
1.64873	1.62697	1.50112	1.31463	1.26495	1.14429	1.04888	0.93088
25	26	27					
0.86396	0.75546	0.54651					

ITERATIVE PRINCIPAL AXIS FACTOR ANALYSIS

FINAL COMMUNALITY ESTIMATES

1	2	3	4	5	6	7	8
0.39688	0.68507	0.36118	0.47976	0.24554	0.36607	0.72998	0.42593
9	10	11	12	13	14	15	16
0.32244	0.36686	0.38362	0.69470	0.64574	0.36643	0.74446	0.30104
17	18	19	20	21	22	23	24
0.34720	0.63412	0.42525	0.56458	0.5029	0.40719	0.49337	0.36497
25	26	27	28	29			
0.48457	0.28284	0.46944	0.35394	0.12708			

TABLE 3 (con t.)

ROTATED FACTOR PATTERN

ITEM	Factor 2	Factor 2
ATT(1)	0.59274	0.21340
ATT(2)	0.07362	0.82441
ATT(3)	0.57991	0.15774
ATT(4)	0.12254	0.68172
ATT(5)	0.45480	0.19672
ATT(6)	0.54747	0.25757
ATT(7)	0.22338	0.82467
ATT(8)	0.47168	0.45106
ATT(9)	0.55557	0.11742
ATT(10)	0.59742	0.09975
ATT(11)	0.61321	0.08718
ATT(12)	0.37734	0.74318
ATT(13)	0.74836	0.29273
ATT(14)	0.30370	0.52363
ATT(15)	0.25250	0.82505
ATT(16)	0.38724	0.38869
ATT(17)	0.58785	0.04038
ATT(18)	0.02724	0.79585
ATT(19)	0.50806	0.40881
ATT(20)	0.66346	0.35270
ATT(21)	0.69985	0.11469
ATT(22)	0.62957	0.10404
ATT(23)	0.68228	0.16692
ATT(24)	0.50698	0.32854
ATT(25)	0.04106	0.69490
ATT(26)	0.53075	0.03393
ATT(27)	0.22903	0.64574
ATT(28)	0.54905	0.22909
ATT(29)	0.23991	0.26368

PERCENT OF TOTAL VARIANCE EXPLAINED

1	2
23.74189	20.99327

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TABLE 4
Multiple Regression Using All Predictors

N = 177; R^2 = .117; p = .03253

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	1.26203	0.81756	0.00000	1.54366	0.12459
SDS	0.08991	0.02792	0.29530	3.22002	0.00154
CLOZE	0.02605	0.02738	0.07482	0.95125	0.34287
Sex	-0.01127	0.10751	-0.00998	-0.10479	0.91667
Course1	0.04108	0.18342	0.01765	0.22400	0.82304
Course2	-0.09164	0.13783	-0.05032	-0.66491	0.50704
Course3	-0.08520	0.15682	-0.04175	-0.54332	0.58765
I1	0.02622	0.17570	0.01154	0.14925	0.88154
I2	-0.06451	0.13900	-0.04230	-0.46412	0.64317
I3	0.09268	0.15571	0.04860	0.59521	0.55252
ATS FIELD	0.01028	0.01130	0.08734	0.91039	0.36395
ATS COURSE	-0.00690	0.01548	-0.04938	-0.44597	0.65621

N = 177; R^2 = .113; p = .00837

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	1.20772	0.80284	0.00000	1.50431	0.13438
SDS	0.09006	0.02770	0.29577	3.25079	0.00139
CLOZE	0.02702	0.02696	0.07760	1.00231	0.31764
Sex	-0.01418	0.08407	-0.01256	-0.16868	0.86625
Course1	0.04081	0.18179	0.01754	0.22449	0.82265
Course2	-0.08153	0.13492	-0.04477	-0.60432	0.54645
Course3	-0.09542	0.15489	-0.04676	-0.61605	0.53869
ATS FIELD	0.01075	0.01095	0.09134	0.98247	0.32728
ATS COURSE	-0.00663	0.01519	-0.04741	-0.43617	0.66327

N = 177; R^2 = .113; p = .00440

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	1.22004	0.79720	0.00000	1.53040	0.12779
SDS	0.09001	0.02762	0.29563	3.25875	0.00135
CLOZE	0.02665	0.02679	0.07656	0.99485	0.32123
Course1	0.03762	0.18029	0.01617	0.20869	0.83494
Course2	-0.07932	0.13389	-0.04356	-0.59243	0.55436
Course3	-0.09492	0.15442	-0.04651	-0.61473	0.53956
ATS FIELD	0.01051	0.01082	0.08923	0.97139	0.33274
ATS COURSE	-0.00620	0.01494	-0.04436	-0.41506	0.67863

N = 177; R^2 = .111; p = .00109

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	1.19769	0.75726	0.00000	1.58162	0.11557
SDS	0.09031	0.02712	0.29666	3.33047	0.00106
CLOZE	0.02397	0.02612	0.06880	0.91771	0.36005
Sex	-0.00680	0.08233	-0.00604	-0.08256	0.93430
ATS FIELD	0.00986	0.01046	0.08369	0.94236	0.34733
ATS COURSE	-0.00454	0.01442	-0.03254	-0.31468	0.75339

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TABLE 4 (cont.)

N = 178; R^2 = .110; p = .00042

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	1.20258	0.75277	0.00000	1.59754	0.11197
SDS	0.09029	0.02704	0.29659	3.33945	0.00103
CLOZE	0.02384	0.02600	0.06844	0.91706	0.36039
ATS FIELD	0.00976	0.01036	0.08282	0.94191	0.34755
ATS COURSE	-0.00435	0.01420	-0.03119	-0.30634	0.75971

N = 177; R^2 = .042; p = .19436

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	2.46466	0.72576	0.00000	3.39598	0.00085
ATS FIELD	0.00450	0.01104	0.03826	0.40809	0.68372
ATS COURSE	.02245	0.01310	0.16065	1.71459	0.08823
GP1	-0.08495	0.18140	-0.03650	-0.46830	0.64017
GP2	-0.07812	0.13817	-0.04290	-0.56537	0.57256
GP3	-0.03244	0.15786	-0.01590	-0.20551	0.83742

N = 183; R^2 = .105; p = .000005

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	1.88245	0.36950	0.00000	5.09461	0.00000
SDS	0.09078	0.02226	0.30145	4.07780	0.00007
CLOZE	0.01993	0.02494	0.05909	0.79933	0.42515

N = 178; R^2 = .037; p = .03659

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	2.32077	0.69839	0.00000	3.32302	0.00108
ATS FIELD	0.00583	0.01066	0.04953	0.54736	0.58483
ATS COURSE	0.02230	0.01262	0.15992	1.76728	0.07892

TABLE 5
Multiple Regression by Course

Masters-level (N=31)

R^2 = .360; p = .03775

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	-0.00076	1.87926	0.00000	-0.00041	0.99968
ATS FIELD	0.00258	0.03161	0.01831	0.08149	0.93570
ATS COURSE	0.03139	0.04904	0.16107	0.64009	0.52794
SDS	0.14125	0.05844	0.47206	2.41703	0.02327
CLOZE	0.02110	0.06230	0.06216	0.33861	0.73773
Sex	-0.01251	0.18860	-0.01107	-0.06632	0.94765

R^2: .360; p = .01716

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	-0.02259	1.81444	0.00000	-0.01245	0.99016
ATS FIELD	0.00311	0.02998	0.02210	0.10370	0.91820
ATS COURSE	0.03072	0.04708	0.15767	0.65265	0.51971
SDS	0.14168	0.05694	0.47352	2.48817	0.01957
CLOZE	0.02062	0.06069	0.06076	0.33977	0.73676

Doctoral-level Inferential Statistics (N=85)

R^2: .189; p = .00483

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	0.62875	1.13370	0.00000	0.55460	0.58073
ATS FIELD	0.00990	0.01525	0.08219	0.64879	0.51836
ATS COURSE	-0.01254	0.01985	-0.09290	-0.63191	0.52927
SDS	0.11983	0.03751	0.39463	3.19494	0.00201
CLOZE	0.05319	0.03632	0.15251	1.46425	0.14709
Sex	-0.06271	0.12012	-0.05510	-0.52206	0.60309

R^2: .186; p = .00225

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	0.67800	1.12462	0.00000	0.60286	0.54830
ATS FIELD	0.00840	0.01491	0.06977	0.56331	0.57480
ATS COURSE	-0.01018	0.01924	-0.07543	-0.52932	0.59805
SDS	0.12008	0.03733	0.39546	3.21655	0.00187
CLOZE	0.05391	0.03613	0.15458	1.49192	0.13965

Doctoral-level Multiple Linear Regression (N= 49)

R^2: .031; p = 0.92422

VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	3.07079	1.86453	0.00000	1.64695	0.10686
ATS FIELD	0.01047	0.02445	0.08804	0.42809	0.67072
ATS COURSE	0.00025	0.03562	0.00176	0.00707	0.99439
SDS	0.01302	0.06625	0.04056	0.19652	0.84513
CLOZE	-0.05647	0.07509	-0.12449	-0.75199	0.45615
Sex	0.10553	0.19800	0.08564	0.53295	0.59681

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TABLE 5 (cont.)

R^2: .025; p = .89096					
VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	2.76134	1.75735	0.00000	1.57131	0.12327
ATS FIELD	0.01478	0.02289	0.12431	0.64579	0.52177
ATS COURSE	-0.00462	0.03414	-0.03227	-0.13522	0.89305
SDS	0.01471	0.06563	0.04582	0.22412	0.82370
CLOZE	-0.04964	0.07339	-0.10942	-0.67636	0.50235

Doctoral-level Experimental Design (N=12)

R^2: .862; p = .01470					
VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	1.49020	0.64635	0.00000	2.30557	0.06064
ATS FIELD	0.01111	0.01037	0.26762	1.07093	0.32538
ATS COURSE	0.05161	0.01153	0.94173	4.47681	0.00421
SDS	-0.02140	0.04847	-0.11203	-0.44153	0.67430
CLOZE	-0.00278	0.01812	-0.02989	-0.15332	0.88317
Sex	0.14775	0.10760	0.39090	1.37313	0.21882

R^2: .818; p=.00986					
VARIABLE	COEFF.	STD ERR	BETA	t	P(2 TAIL)
Constant	1.60717	0.68003	0.00000	2.36338	0.05009
ATS FIELD	0.00112	0.00785	0.02693	0.14247	0.89072
ATS COURSE	0.04411	0.01077	0.80487	4.09367	0.00461
SDS	0.02509	0.03681	0.13135	0.68162	0.51739
CLOZE	0.01267	0.01508	0.13627	0.83997	0.42868